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THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION.

W. A. WITHERS, A. M., ACTING DIRECTOR.

THE ADULTERATION OF FLOUR

AS IT IS FOUND TO EXIST IN SAMPLES PURCHASED UPON THE MARKETS IN NORTH CAROLINA.

W. A. WITHERS AND G. S. FRAPS.

RALEIGH, N. C.

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THE ADULTERATION OF FLOUR.

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G. S. FRAPS, B. S., ASSISTANT CHEMIST

This bulletin is one of a series which has for its object the determination of the extent and character of the adulterations practiced in North Carolina.

The most common articles of food are the subject of these investigations; those which every one must consume in large quantities. Bulletins on vinegar, baking powders, coffee and tea have already appeared. Flour is supposed to be subjected to less adulteration in this country than any other article of food. Nevertheless, its purity is not a thing to be assumed without question, as shown by the facts presented below.

ACKNOWLEDGMENT.

In the preparation of this bulletin use was made of the well known works of Hassall, Blyth, and Battershall, on food adulteration, and of Sadtler's Industrial Organic Chemistry. Special mention is due the service rendered by Bulletin 13, Division of Chemistry, United States Department of Agriculture. This bulletin, on Foods and Food Adulterations, prepared under the direction of Dr. Harvey W Wiley, is composed of several parts. The last part is devoted to cereals and cereal products; frequent quotations from it will be found in the following pages.

FLOUR.

Milling. A grain of wheat consists of three parts, the germ, the floury matter, and the outer covering. It is really an embryo plant packed together with sufficient food to give it a good start in life, and surrounded by layers of a protective tissue. The germ, floury matter, and outer covering differ much in composition, color, and other properties, and are not of uniform character themselves. The most primitive way of preparing flour is to crush or grind the whole grain. In the next stage, the outer envelope or bran is removed from the flour by sifting. The process became more and more complex, and the wheat grain is now separated into a great number of products, each with certain distinct characteristics. Until about twenty-five years ago wheat was simply ground between stones, sifted through bolting cloths of different degrees of fineness, and separated into bran and two or three other pro-

ducts, as shorts, middlings and flour. In the high-grade roller mills of the present day from 80 to 100 products are formed from the time the wheat enters the mill until the finished products are offered for sale. The mill is called a roller mill because steel rollers replace the old-time mill-stone, rollers arranged in pairs with spiral grooves of various degrees of depth and fineness, revolving towards each other. The grain passes from a coarse set of rollers to a bolter, or sifting cloth, the products to finer rollers, and so on. It is reduced in fineness step by step, thus permitting a more perfect separatiou of the different parts of the wheat, and the practically entire separation of the bran and the germ from the starchy products of the grain. The miller does not offer 80 to 100 things for sale. These are only intermediate stages: the waste parts are mixed and sold for cattle feeding, as bran, shipstuff, etc., and from the others are compounded flours of different qualities. All the high grade mills produce several grades of flour from the same sample of wheat. The highest grade is usually called a "Patent" flour, then follow, in order of decreasing quality, "Straight," "Clear," and "Extra" flours. This method of nomenclature is not adopted by all millers; some call their lower grades "Family," "Bakers," and "Red Dog" flours. The grading of flours depends upon the miller, who is guided more by color and general appearance than anything else.

Composition.—Chemical analysis will give a basis for calculating the value of a food to the animal organism, which value must not be understood as the same as market value. Flour consists mainly of starch, and a substance containing nitrogen called gluten, which is an albuminiod. The substance the chemist calls albuminiods or protein is needed by the animal organism for the building and repair of the body, to make blood, muscle, bone. Oils, fatty substances, and carbohydrates as starch and sugar, are needed by the body for fuel to furnish heat to keep it warm, to furnish muscular strength for its work. The amount of these two classes of nutrients present determines in general the usefulness of the food to the body. The nutritive value of a food can be measured by the muscle-forming material it contains and the heat it will supply; it can be expressed in terms of protein and heat. Muscle is more expensive than fuel—the frame of the locomotive is worth more than the coal it consumes. The heat-unit is called *calorie*, and is the amount of heat required to raise the temperature of 1 gram (.0353 oz.) water 1 degree Centigrade. The following table* gives the composition of different classes of flour, and allows a comparison of their value for food, according to present standards. For the purpose of comparing the food values, only the results in the first two columns need be regarded. A glance at the table shows that

*Bull. 13, Division of Chemistry, U. S. Department of Agriculture.

the Bakers and Family flours contains a greater per cent. of muscle-forming material, and will furnish more heat to the ounce than either of the other classes. The Patent flour, so far as its use as a nutrient is concerned, is worth no more than common market flour, and less than Bakers flour. Yet the Patent flour sells for more than the others. This brings out very clearly the fact that the price of a flour bears no relation to its value as a food; what it brings in the market is entirely independent of its chemical composition, and is based upon color, taste and other similar characteristics.

	Calories per Gram.	Protein Nx5.70.	Carbohydrates Nx5 70.	Fats. (Ether Extract.)
Patent Flour—40 Samples.				
Maximum	4,040	13.62	79.88	1.86
Minimum	3,707	6.23	71.94	0.32
Average	3,858	9.62	76.14	1.02
Common Market Flour—19 Samples.				
Maximum	4,156	14.54	80.41	3.84
Minimum	3,790	6 06	70.29	.34
Average	3.882	9.28	76.53	1.30
Bakers and Family Flour—14 Samples.				
Maximum	4,072	13.65	71.89	1.97
Minimum	3,811	9.10	78.85	.82
Average	3,929	11.20	74.98	1.30

The Adulteration of Flour.

The full definition of adulteration, as clearly stated in the law of the State of North Carolina, has already been quoted in full in a preceding bulletin (Coffee and Tea, No. 154). That definition need not be repeated here.

A flour is adulterated, (1) if any substance has been mixed with it so as to reduce or lower or injuriously affect its quality or strength; (2), if any inferior or cheaper substance has been substituted wholly or in part for the article; (3), if it has been treated in any way whereby damage is concealed, or it is made to appear better than it really is.

The works on food adulteration state that in the United States adulterated flour is of extremely rare occurrence. This is due to its cheapness. If the price of flour rises, there is increased danger of admixture. It is therefore well to know those substances which have been mixed with flour, and the chief methods of detecting them. But this work will show that, in spite of the cheapness of flour, it is adulterated to a considerable extent. The assumption that any flour is unadulterated is unwarranted, and it should be subjected to as severe an examination as any other article of food.

1. Vegetable additions. The following substances have been detected as adulterations in flour: Rye flour, rice meal, barley meal, potato flour, linseed meal, buckwheat flour, corn flour, and

the flour of various leguminosae, as peas, beans. With the exception of corn flour or corn meal, all these are of rare occurrence in this country.

"In regard to the use of Indian-corn meal for mixing with wheaten flour in this country, a prominent army officer of large experience in the Commissary Department, under date of March 20, 1897, gives the following information:

The Indian-corn flour used in adulterating wheat flour is especially prepared at at least two mills in this section of the country, one in Cincinati and the other in Kansas, and such Indian-corn flour is not put upon the market at all. It is made and solely prepared for use in adulterating wheat flour. To an unpracticed eye the corn flour made at the Cincinnati mill, without any mixture, could be passed off as spring-wheat flour. It has the same feel and the same appearance to the inexpert; of course it lacks taste and color when critically examined, but it is of such a nature that it is difficult to detect it in mixtures even though in very large proportions."—*Bulletin 13, Division of Chemistry, U. S. Department of Agriculture.*

As will be seen, corn flour was detected in several of the samples examined in the course of this investigation.

After corn flour, the most probable vegetable adulterant of American flour would be pea flour, and then bean flour. The wider-spread growth of the cow-pea in the Southern States, and its cheapness, would lead one to be on the watch for its appearance ground with flour.

Detection. Wheaten flour, as well as the flours of the vegetable substances sometimes mixed with it, consists largely of starch. The appearance of starch when highly magnified shows its origin. Starch possesses an organized structure which differs in different kinds of plants. Under the microscope wheat flour is seen "to consist of different grains or particles; many of these are very small, others are of considerable dimensions; the small grains are chiefly round, rarely oval, and for the most part provided with a central spot or hilium: the larger granules form rounded or flattened discs, with thin edges."* The granules of rice starch and corn starch are angular, and have a well defined star or depression in the center. Pea starch and bean starch have an oval shape, and a prominent central mark, a long, more or less stellate, air-filled black hollow. Potato starch is made up of concentric rings, has an excentric hilium, and gives a play of colors with a selenite plate and polarized light. Wheat starch does not appear colored under these conditions. These and other differences enable one who is familiar with the starches to determine the plant from which a particular starch came, or to decide whether it is

*Hassall.

homogeneous or a mixture, by an examination with the microscope. If wheat flour has been adulterated with peas or corn, the microscope will reveal it.

Chemical methods are known which can be used to detect vegetable adulterations in flour. They will not be described here.

II. *Mineral additions.* A recent Bulletin of the United States Department of Agriculture* is authority for the following: "The use of gypsum, terra alba or other inert white earthy powders has never been detected as an adulteration in flour or bread in the samples examined in this laboratory. No authentic record of such adulteration in the United States is at hand. "In *The American Grocer*, (New York,) of June 15, 1898, an article appeared containing a letter from the York Manufacturing Company, of Greensboro, N. C., offering mineraline for use as an adulterant in flour and other articles of food." Many adulterations of this kind are reported in foreign countries. In one instance a wheat flour was reported to contain 53.5 per cent. of gypsum. In nine flours examined in Gratz, one was found which contained 39 per cent. of gypsum."

This shows that those who examine flour for adulterations must always test for mineral matter.

Detection.—When pure flour is burned, the ash left seldom exceeds 0.90 %, although cases are known in which it has reached 2.0 per cent. The addition of mineral matter to flour in sufficient quantity to render its use as an adulterant profitable would increase the per cent. of ash greatly. A flour containing ten per cent. mineral matter would yield over ten per cent. ash.

III. Mineral additions to enhance apparent value. Alum, carbonate of soda and carbonate of magnesia, are added to flour to improve its appearance. Carbonate of soda and carbonate of magnesia are rarely used. Alum is employed to disguise the presence of damaged flour in mixtures, or to improve the appearance of an inferior grade; its addition to a damaged flour serves to arrest decomposition of the gluten, thereby preventing the flour from acquiring a dark color and disagreeable odor and taste.

Alum in appreciable quantities is injurious, having a retarding influence on the digestion. In the small quantity in which it is added to flour, alum may or may not impair the health; that question is still unsettled. But since alum is added for the purpose of causing the purchaser to believe he is obtaining a better article than he really does, there can be no difference of opinion that it is a serious adulteration, and not to be permitted. According to the definition already given, the presence of alum is a clear case of adulteration.

Detection.—The flour is made into a paste with a little water and a few drops of an alcoholic solution of logwood; a little am-

*Bulletin 13, Division of Chemistry.

monium carbonate is then added. If alum be present the color changes to lavender blue, while, if no alum is present, the resulting tint is only a faint pink. Another method may be used, which consists in separating the alum, as such, from the flour. A quantity of the flour to be tested is shaken with chloroform in a separating funnel, and allowed to stand. The alum sinks to the bottom, together with other mineral matter and some flour. The subsided particles are separated and treated with chloroform as before. The alum is dissolved from the particles, which sink with water, and is identified by its properties.

Examinations of Samples of Flour.

The samples were collected from stores of different grades, most of them by purchase. The last three samples, numbers 10561, 10673, 10645, were sent to the Station as suspicious flours by parties not connected with the Station. The table gives a description of the samples.

Most of the samples in the table came from flours which were sold in packages as small as one-sixteenth of a barrel—or 12¼ lb. sacks. Some few were sold in half-barrel sacks only.

DESCRIPTION OF SAMPLES.

Date Obtained.	Serial Number.	Brand.	Manufacturer.	Where Obtained.
1898.				
June 18	1026	.....	.....	Raleigh.
	1027	Imperial	.....	Raleigh.
	1028	Jersey Lily	.....	Raleigh.
	1029	Royal Patent.....	.....	Raleigh.
	1030	.....	.....	Raleigh.
July 12	1031	Jeff Davis.....	Sweet Water Milling Co., Sweet Water, Tenn.	Statesville.
	1032	Royal Straight...	Rayner, Miller & Co.....	Statesville.
	1033	"Extra Choice"..	Fresno Milling Co	Statesville.
	1034	Oven Lifter.....	Statesville Roller Mills	Statesville.
	1033	Sylvan Bell.....	Sweet Water Mills Co., Sweet Water, Tenn.	Statesville.
	1036	Carolina Choice...	Statesville Roller Mills	Statesville.
	1037	Dan Valley	Dan Valley Mills, Danville, Va.	Statesville.
	1038	De Soto.....	Dan Valley Mills, Danville, Va.	Statesville.
	1039	Oak Ridge.....	Dan Valley Mills, Danville, Va.	Statesville.
	1040	Cedar Cliff.....	Dan Valley Mills, Danville, Va.	Statesville.
Aug. 22.	1145	Royal Crown.....	Stuart Draft Milling Co., Stuart Draft, Va.	Raleigh.
	1146	Bon Ton Patent...	White Star Mills. Staunton, Va.	Raleigh.

Date Obtained.	Serial Number.	Brand.	Manufacturer.	Where Obtained.
	1147	City Pride	Farina Roller Mills, Raleigh, N. C.	Raleigh.
	1148	Golden Star	New Market Roller Mills, New Market, Va.	Raleigh.
	1149	Oak City Straight	Farina Roller Mills, Raleigh	Raleigh.
	1150	Calla Lily	White Star Mills, Staunton, Va.	Raleigh.
	1151	Acme Patent	Strasburg Steam Flouring Mills, Strasburg, Va.	Raleigh.
	1152	Obelisk Patent	Ballard, Louisville	Raleigh.
Sept. 15.	1159	Monarch	J. I. Triplet, Woodstock, Va.	Durham.
	1160	White Rock	S. C. Hurts & Son, Lynchburg, Va.	Durham.
	1161	White Violet	Strasburg Flour Mills, Strasburg, Va.	Durham.
	1162	Snow Flake	——, Strasburg, Va.	Durham.
Sept. 17.	1172	Roller Champion		Raleigh.
	1173	White Rose		Raleigh.
	1174	Melrose	——, Staunton, Va	Raleigh.
	1175	Nickel Plate	Model Mills, Nashville, Tenn.	Raleigh.
	1176	Panola	Model Mills, Nashville, Tenn.	Raleigh.
	1178	White Flint		Raleigh.
	1179	Union	——, Tenn	Raleigh.
	1180	Magnolia	——, Virginia	Raleigh.
	1181	Pride of the Valley	——, Stephens City, Va.	Raleigh.
	1182	Imperial	Crickenberger & Hottel, New Market, Va.	Raleigh.
	1183	Purity	Strasburg Steam Flouring Mills Strasburg, Va.	Raleigh.
	1184	Water Lily	Strasburg Steam Flouring Mills, Strasburg, Va.	Raleigh.
	1185		——, North Carolina	Raleigh.
	1186	Crescent	——, Tennessee	Raleigh.
	1187	New Process	White Star Mills, Staunton, Va.	Raleigh.
	1188	Waverly	Strasburg Steam Flouring Mills.	Raleigh.
	1189	Waterloo	Ballard, Louisville	Raleigh.
	1203	Old Gold	Strasburg Steam Milling Co.	Henderson.
	1204	Royal Patent	White Star Mills, Staunton, Va.	Henderson.
	10561	Canopy	Cumberland Mills, Nashville, Tenn.	Scotland Neck.
	10673	Biltmore Patent	Asheville Milling Co, Asheville, N. C.	Asheville.
	10645	Golden Sheaf		Fayetteville.

I. Vegetable adulterations.—An examination with the microscope showed that the following flours were adulterated:

1031. Jeff. Davis, 6.6 per cent. corn flour.
1035. Sylvan Bell, 7.6 per cent. corn flour.
1040. Cedar Cliff, 10.6 per cent. corn flour.
1179. Union, 12.5 per cent. corn flour.
1186. Crescent, 20 per cent corn flour.

1189. Waterloo, corn meal. Not determined.
10645. Golden Sheaf, 39 per cent. corn flour.
10561. Canopy, 12.3 per cent. corn flour.

All of the above were cheap flours. None of the patent flours contained any adulterant. Numbers 1179 and 1186 were only in half-barrel sacks. Number 1189 contained a quantity of corn meal, the percentage of which could not be determined by the method described below.

Fifty samples flour examined; eight samples adulterated with corn flour or corn meal—16 per cent.

Determination of corn flour in wheat flour.—The only method available is very approximate. Dr. Ewell describes it in full in the Journal of Applied Microscopy, Vol. 1, page 122. Briefly, the method is as follows: One gram of the sample is well mixed with 20 cc of a mounting fluid composed of glycerine, acetic acid and water, and a drop of the mixture placed on a slide for examination under the microscope. The number of corn starch granules and wheat starch granules visible in a certain field are counted, using a slide divided into squares in the eye-piece of the microscope as an aid. One thus counts ten fields of view, and calculates the ratio of corn starch to wheat starch granules. A mixture of known composition is subjected to the same treatment, and from the ratio of the granules in this, the composition of the unknown flour is calculated. The method is approximate only. Working on mixtures of corn starch and flour, prepared in proportions unknown to him, Ewell obtained 29.3 per cent., 3.83 per cent., and 16.0 per cent. corn starch, instead of 32.5 per cent., 7.75 per cent., and 21. per cent respectively, and the writer calculated 8.5 per cent. in mixture instead of 5.0 per cent., which was its true composition.

If a sample of the adulterant could be used to make the standard mixture, the result would approximately represent the percentage of adulteration. Such a sample cannot be obtained, and corn starch had to be used, so that not the per cent. of adulteration, but of corn starch, is reached. The average amount of starch in Indian corn flour analyzed by the U. S. Department of Agriculture is 78 4 per cent. With this figure as a basis, and determining the amount of corn starch in the flours by the method just described, the percentages of adulteration was reached which are given in the above table.

II. Mineral additions.—No clay, soapstone, mineraline or any other such minerals were detected in any of the flours examined. The per cent. of ash in the flours is given in the table.

PERCENTAGES OF ASH.

Serial No.	Ash.	Serial No.	Ash.	Serial No.	Ash.
1026	0.30	1037	0.38	1161	0.41
1027	0.45	1039	0.49	1162	0.43
1028	0.44	1040	0.77	1172	0.39
1029	0.32	1145	0.34	1173	0.52
1030	0.39	1146	0.34	1180	1.05
1031	0.64	1147	0.48	1183	0.46
1032	0.51	1149	0.46	1184	1.06
1033	0.71	1150	0.36	1185	0.68
1034	0.80	1151	0 38	1187	0.39
1035	0.47	1152	0.41	1189	0.65
1036	0.49	1159	0.41	10645	0.48
1037	0.36	1160	0 47	10561	0 43
				10673	0.34

III. Mineral additions to enhance apparent value.

Twenty-seven of the flours were subjected to the logwood test for alum. In one case only was alum found:

No. 1031, Jeff Davis.

One in twenty-seven, or almost 4 per cent.

Summary.

American flour is adulterated with corn flour. Mills exist which have the preparation of corn flour for use as an adulteration their only object.

Sixteen per cent. of the flours examined by us contained corn flour.

If the number of Patent flours examined were left out of consideration, and only the cheap flours regarded, over twenty per cent. were adulterated with corn flour.

Foreign flour is adulterated with mineral matter, such as clay and plaster of Paris.

Ground soapstone has been offered for sale in North Carolina for use in the adulteration of flour.

American flour sometimes contains alum. One sample examined by us contained alum. Dr. Battershall states that this is the most common adulterant of our flour; this work seems to give corn flour the leading place as an adulterant of wheat flour.

A national law requires an internal revenue stamp affixed to packages of flour with which corn flour has been mixed. Without some one to execute the law it is without effect.